

## 1. PUBLIC HEALTH STATEMENT

This public health statement tells you about cyanide and the effects of exposure.

The Environmental Protection Agency (EPA) identifies the most serious hazardous waste sites in the nation. These sites make up the National Priorities List (NPL) and are the sites targeted for long-term federal cleanup. Cyanide has been found in at least 84 of the 1,430 current or former NPL sites. However, it's unknown how many NPL sites have been evaluated for this substance. As more sites are evaluated, the sites with cyanide may increase. This information is important because exposure to this substance may harm you and because these sites may be sources of exposure.

When a substance is released from a large area, such as an industrial plant, or from a container, such as a drum or bottle, it enters the environment. This release does not always lead to exposure. You are exposed to a substance only when you come in contact with it. You may be exposed by breathing, eating, or drinking the substance or by skin contact.

If you are exposed to cyanide, many factors determine whether you'll be harmed. These factors include the dose (how much), the duration (how long), and how you come in contact with it. You must also consider the other chemicals you're exposed to and your age, sex, diet, family traits, lifestyle, and state of health.

### 1.1 WHAT IS CYANIDE?

Cyanide is usually found in compounds (substances formed by joining two or more chemicals). Cyanide can interact with metals and other organic compounds (compounds that include carbon). Sodium cyanide and potassium cyanide are examples of simple cyanide compounds. Cyanide can be produced by certain bacteria, fungi, and algae, and is found in a number of foods and plants. In your body, cyanide can combine with a chemical (hydroxocobalamin) to form vitamin B<sub>12</sub> (cyanocobalamin). In certain plant foods, including almonds, millet sprouts, lima beans,

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soy, spinach, bamboo shoots and cassava roots (potato-like tubers of cassava plants grown in the tropics and known in the United States as tapioca), and in vitamin B<sub>12</sub> cyanide occurs as part of naturally occurring sugars or other complex organic compounds.

Cyanide is a powerful and rapid-acting poison. Hydrogen cyanide has been used in gas-chamber executions and as a war gas.

Much of the cyanide in soil and water comes from industrial processes. The major sources of cyanide in water are discharges from some metal mining processes, organic chemical industries, iron and steel works, and publicly owned waste water treatment works. Other cyanide sources include vehicle exhaust, releases from certain chemical industries, municipal waste burning, and use of cyanide-containing pesticides. Much smaller amounts of cyanide may enter water through storm water runoff in locations where road salts that contain cyanide are used.

Underground water can be contaminated by cyanide present in landfills. Hydrogen cyanide, sodium cyanide, and potassium cyanide are the forms of cyanide most likely to be in the environment as a result of industrial activities. Hydrogen cyanide is a colorless gas with a faint, bitter, almond-like odor. Sodium cyanide and potassium cyanide are both white solids with a slight, bitter, almond-like odor in damp air. Cyanide salts and hydrogen cyanide are used in electroplating, metallurgy, organic chemicals production, photographic developing, making plastics, fumigating ships, and some mining processes. Chlorination of water contaminated with cyanide produces the compound cyanogen chloride. Two incidents of cyanide in soil resulted from disposal of cyanide-containing wastes in landfills and use of cyanide-containing road salts. See Chapters 3 and 4 for more information on physical and chemical properties and on production and use of cyanide.

Thiocyanates are a group of compounds formed when sulfur, carbon, and nitrogen are combined. Thiocyanates are found in various foods and plants; however, they are produced primarily from the reaction of free cyanide with sulfur. This reaction occurs in the environment (for example, in industrial waste streams that contain cyanide) and in the human body after swallowing or absorbing cyanide.

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Ammonium thiocyanate is used as an ingredient in antibiotic preparations, pesticides, liquid rocket fuels, adhesives, and matches. It is also used in photographic processes, to improve the strength of silks, and as a weed killer.

Thiocyanates are present in water primarily because of discharges from coal processing, extraction of gold and silver, and mining industries. Thiocyanates in soil result from direct application of weed killers and disposal of by-products from industrial processes. Less important sources include release from damaged or decaying tissues of certain plants such as mustard, kale, and cabbage.

### 1.2 WHAT HAPPENS TO CYANIDE WHEN IT ENTERS THE ENVIRONMENT?

Cyanide enters air, water, and soil as a result of both natural processes and industrial activities. Airborne cyanide is generally far below levels that would cause concern. In air, cyanide is present mainly as gaseous hydrogen cyanide. A small amount of cyanide in air is present as fine dust particles. This dust eventually settles over land and water. Rain and snow help remove cyanide particles from air. The gaseous hydrogen cyanide is not easily removed from the air by settling, rain, or snow. The half-life (the time needed for half the material to be removed) of hydrogen cyanide in the atmosphere is about 1 to 3 years. Most cyanide in surface water will form hydrogen cyanide and evaporate. Some cyanide in water will be transformed into less harmful chemicals by microorganisms (plants and animals of very small size), or will form a complex with metals, such as iron. The half-life of cyanide in water is not known. Cyanide in water does not build up in the bodies of fish.

Cyanide in soil can form hydrogen cyanide and evaporate. Some of the cyanide will be transformed into other chemical forms by microorganisms in soil. Some forms of cyanide remain in soil, but cyanide usually does not seep into underground water. However, cyanide has been detected in underground waters of a few landfills. At the high concentrations found in some landfill leachates (water that seeps through landfill soil), cyanide becomes toxic to soil microorganisms. Since these microorganisms can no longer change cyanide to other chemical

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forms, cyanide is able to pass through soil into underground water. See Chapters 4 and 5 for more information about what happens to cyanide in the environment.

Less is known about what happens to thiocyanates when they enter the environment. In soil and water, thiocyanates are changed into other chemical forms by microorganisms. At near normal temperatures (30 °C), evaporation or sorption (binding to soil) does not seem to be important for thiocyanates in soil.

See Chapters 4 and 5 for more information about what happens to thiocyanates in the environment.

### 1.3 HOW MIGHT I BE EXPOSED TO CYANIDE?

You may be exposed to cyanide by breathing air and drinking water, touching soil or water containing cyanide, or eating foods that contain cyanide. Many plant materials, such as cassava roots, lima beans, and almonds, naturally contain low-to-moderate levels of cyanide. The concentration of hydrogen cyanide in unpolluted air is less than 0.0002 parts per million (ppm; 1 ppm is equivalent to 1 part by volume of hydrogen cyanide in a million parts by volume of air). Cyanogen chloride, which might be formed in the process of water chlorination, has been found at concentrations ranging from 0.00045 to 0.0008 ppm (1 ppm is equivalent to 1 part by weight in a million parts by volume of water) in drinking water from 35 United States cities. We do not know how many people in the general population of the United States are exposed to significant amounts of cyanide from eating foods that naturally contain cyanide. Smoking is probably one of the major sources of cyanide exposure for people who do not work in cyanide related industries. Breathing smoke-filled air during fires may also be a major source of cyanide exposure. People who live near hazardous waste sites that contain cyanide may also be exposed to higher amounts of cyanide compared with the general population.

Cyanide is used or produced in various occupational settings where activities include electroplating, some metal mining processes, metallurgy, metal cleaning, certain pesticide applications, tanning, photography and photoengraving, firefighting, and gas works operations.

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Cyanide is also used in some dye and pharmaceutical industries. The National Occupational Exposure Survey (NOES) has estimated the numbers of workers who are potentially exposed to the following forms of cyanide: 4,005 to hydrogen cyanide; 66,493 to sodium cyanide; 64,244 to potassium cyanide; 3,215 to potassium silver cyanide; 3,606 to calcium cyanide; 22,339 to copper (I) cyanide; and 1,393 to cyanogen chloride. See Chapter 5 for more information on exposure to cyanide.

You can be exposed to thiocyanate in the same ways that you may be exposed to cyanide. Exposure to cyanide will also expose you to thiocyanate because cyanide is changed to thiocyanate in your body. Many foods (plants, dairy products, meat) contain thiocyanate. People who work in cyanide-related industries such as the manufacture of electronic computing equipment, commercial printing, photographic processes, hospitals, production of adhesives, and construction and furniture manufacture may be exposed to thiocyanate. No information is available on the concentrations of thiocyanate in unpolluted air or drinking water. We do not know how many people in the general United States population are exposed to significant amounts of thiocyanate from eating foods that contain thiocyanate. People who smoke or breathe tobacco smoke in the environment, and fetuses of mothers exposed to environmental tobacco smoke, may be exposed to high levels of thiocyanate. People who live near hazardous waste sites that contain thiocyanate may potentially be exposed to higher amounts of thiocyanate than the general population. The NOES estimates that a total of 90,599 workers are potentially exposed to ammonium thiocyanate.

### 1.4 HOW CAN CYANIDE ENTER AND LEAVE MY BODY?

Cyanide can enter your body if you breathe air, eat food, or drink water that contains cyanide. Cyanide can enter your body through the skin, but this is common only for people who work in cyanide-related industries. Exposure to contaminated water, air, or soil can occur at hazardous waste sites. Once it is in your body, cyanide can quickly enter the bloodstream. Some of the cyanide is changed to thiocyanate, which is less harmful, and leaves the body in the urine. Some of the cyanide that enters your body can also combine with hydroxocobalamin to form vitamin B<sub>12</sub>. A small amount of cyanide is converted in the body to carbon dioxide, which leaves the

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body in the breath. Most of the cyanide and its products leave the body within the first 24 hours after exposure. The way cyanide enters and leaves the body is similar in people and animals. You can find more information about the movement of cyanide in the body in Chapter 2.

### 1.5 HOW CAN CYANIDE AFFECT MY HEALTH?

To protect the public from the harmful effects of toxic chemicals and to find ways to treat people who have been harmed, scientists use many tests.

One way to see if a chemical will hurt people is to learn how the chemical is absorbed, used, and released by the body; for some chemicals, animal testing may be necessary. Animal testing may also be used to identify health effects such as cancer or birth defects. Without laboratory animals, scientists would lose a basic method to get information needed to make wise decisions to protect public health. Scientists have the responsibility to treat research animals with care and compassion. Laws today protect the welfare of research animals and scientists must comply with strict animal care guidelines.

Exposure to large amounts of cyanide can be deadly. The severity of the harmful effects depends in part on the form of cyanide, such as hydrogen cyanide gas or cyanide salts. Exposure to high levels of cyanide for a short time harms the brain and heart, and can even cause coma and death. People who breathed 546 ppm of hydrogen cyanide have died after a 10-minute exposure; 110 ppm of hydrogen cyanide was life-threatening after a 1 -hour exposure. People who eat large amounts of cyanide in a short time may die. Some of the first indications of cyanide poisoning are rapid, deep breathing and shortness of breath, followed by convulsions and loss of consciousness. These symptoms can occur rapidly, depending on the amount eaten. The health effects of large amounts of cyanide are similar, whether it is eaten, drunk, breathed, or touched. Skin contact with hydrogen cyanide or cyanide salts can irritate and produce sores. Workers who breathed in amounts of hydrogen cyanide as low as 6 to 10 ppm over a period of years had breathing difficulties, pain in the heart area, vomiting, blood changes, headaches, and enlargement of the thyroid gland.

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Use of cassava roots as a primary food source has led to high blood cyanide levels in some people in tropical countries. Some of them suffered harmful effects to the nervous system, including weakness of the fingers and toes, difficulty walking, dimness of vision, and deafness, but chemicals other than cyanide may have also contributed to these effects. Cyanide exposure from cassava was also linked to decreased thyroid gland function and goiter development. These effects have not been seen at levels of cyanide exposure usually found in foods in the United States; however, some children who ate large quantities of apricot pits, which naturally contain cyanide as part of complex sugars, had rapid breathing, low blood pressure, headaches, and coma, and some died. There are no reports that cyanide can directly cause birth defects or reproductive problems in people. However, birth defects were seen in rats that ate cassava root diets, and adverse effects on the reproductive system were seen in rats and mice that drank water containing sodium cyanide. Other cyanide effects in animal studies were similar to those observed in people. There are no reports that cyanide can cause cancer in people or animals. EPA has determined that cyanide is not classifiable as to its human carcinogenicity (ability to cause cancer).

Vitamin B<sub>12</sub> is a chemical substance containing cyanide that is beneficial to your body because it prevents anemia (iron-poor blood). The cyanide is bound in Vitamin B<sub>12</sub> so that it does not serve as a source of cyanide exposure and cannot harm you. You can find more information on the harmful effects of cyanide in Chapter 2.

### 1.6 IS THERE A MEDICAL TEST TO DETERMINE WHETHER I HAVE BEEN EXPOSED TO CYANIDE?

Blood and urine levels of cyanide and thiocyanate can be measured, and small amounts of these compounds are always detectable in blood and urine. We do not know the exact cyanide exposure levels linked with high levels of cyanide or thiocyanate in body fluids. Harmful effects can occur when blood levels of cyanide are higher than 0.2 parts per billion (ppb), but some effects may happen at lower levels. Tissue levels of cyanide can be measured if cyanide poisoning is suspected. However, cyanide and thiocyanate are rapidly cleared from the body; therefore, blood measurements can only indicate evidence of recent exposure. A bitter, almond-

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like odor in the breath may alert a physician that a person was exposed to cyanide. For more information on the health effects of cyanide and how it can be detected in the environment, read Chapters 2 and 6.

### 1.7 WHAT RECOMMENDATIONS HAS THE FEDERAL GOVERNMENT MADE TO PROTECT HUMAN HEALTH?

The federal government develops regulations and recommendations to protect public health. Regulations can be enforced by law. Federal agencies that develop regulations for toxic substances include the Environmental Protection Agency (EPA), the Occupational Safety and Health Administration (OSHA), and the Food and Drug Administration (FDA). Recommendations provide valuable guidelines to protect public health but cannot be enforced by law. Federal organizations that develop recommendations for toxic substances include the Agency for Toxic Substances and Disease Registry (ATSDR) and the National Institute for Occupational Safety and Health (NIOSH).

Regulations and recommendations can be expressed in not-to-exceed levels in air, water, soil, or food that are usually based on levels that affect animals, then are adjusted to help protect people. Sometimes these not-to-exceed levels differ among federal organizations because of different exposure times (an 8-hour workday or a 24-hour day), the use of different animal studies, or other factors.

Recommendations and regulations are also periodically updated as more information becomes available. For the most current information, check with the federal agency or organization that provides it. Some regulations and recommendations for cyanide include the following: EPA sets rules for the amount of cyanide allowed in drinking water. The highest amount allowed is 200 micrograms of cyanide per liter of water ( $\mu\text{g/L}$ ). EPA also sets limits for amounts of hydrogen cyanide in stored foods that have been treated with cyanide to control pests. Amounts allowed range from 5 ppm in cucumbers, lettuce, radishes, and tomatoes, to 250 ppm in spices. EPA also requires industries to report spills of 1 pound or more of potassium



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silver cyanide and 10 pounds or more of hydrogen cyanide, potassium cyanide, sodium cyanide, calcium cyanide, or copper cyanide.

OSHA sets levels of cyanide that are allowable in workplace air. The permissible exposure limit (PEL) for cyanide salts is 5 milligrams of cyanide per cubic meter of air ( $\text{mg}/\text{m}^3$ ) averaged over an 8-hour workday and 40-hour workweek. NIOSH sets guidelines for chemicals in workplace air. Their recommended exposure limit (REL) for workers for 10 minutes is  $5 \text{ mg}/\text{m}^3$  for calcium cyanide, hydrogen cyanide, potassium cyanide, and sodium cyanide.

For more information on regulations and advisories for cyanide in the environment or workplace, read Chapter 7.

### 1.8 WHERE CAN I GET MORE INFORMATION?

If you have any more questions or concerns, please contact your community or state health or environmental quality department or

Agency for Toxic Substances and Disease Registry  
Division of Toxicology  
1600 Clifton Road NE, Mailstop E-29  
Atlanta, GA 30333

\* Information line and technical assistance

Phone: (404) 639-6000  
Fax: (404) 639-6315

ATSDR can also tell you the location of occupational and environmental health clinics. These clinics specialize in recognizing, evaluating, and treating illnesses resulting from exposure to hazardous substances.

\* To order toxicological profiles contact

National Technical Information Service  
5285 Port Royal Road  
Springfield, VA 22161  
Phone: (800) 553-6847 or (703) 487-4650

